The use of tissue temperature control for thermal capsulorrhaphy

Gary S. Fanton, M.D.
Tissue Temperature-Controlled Thermal Capsulorrhaphy
As described by Gary S. Fanton, M.D.

Arthroscopic surgical techniques are generally challenging procedures that require advanced psychomotor operative skills. Common examples are arthroscopic labral, rotator cuff, and meniscal repair procedures demanding advanced application skills as well as decisive pre- and intraoperative clinical judgment.

Monopolar thermal capsulorrhaphy is no different. It demands advanced application skills to ensure that the final operative construct will result in a satisfactory clinical outcome.

Fortunately, monopolar thermal capsulorrhaphy can be readily mastered. When its application principles are fully appreciated, the procedure will become a mainstay for both novice and experienced arthroscopic surgeons.

The surgical techniques described in this technique guide present a paradigm for the application of monopolar thermal capsulorrhaphy. This technique guide describes pathologic shoulder instability based on anatomy, capsular mechanics, and treatment through thermal modification of collagen.

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Overview

Mechanics of Shoulder Instability

The mechanisms contributing to glenohumeral stability are complex and varied. The rotator cuff is the dominant contributor to stability through the mid-arcs of motion by enhancing concavity compression. This is why physical therapy and rehabilitation that emphasize strength restoration and coordination are so essential to clinical success following shoulder surgery for instability.

At end ranges of motion, the capsular ligamentous system is responsible for shoulder stability. As the shoulder position varies from abduction to adduction and internal to external rotation, varying components of the capsular ligamentous system are responsible for static shoulder stability.

The nature of individual ligament contribution to overall static stability has been identified through biomechanical cutting studies of cadaveric shoulders. A complete review of these studies can be found in Clinics in Sports Medicine (1995; 14:751–760).

Anterior Translation Static Stabilizers

The primary restraint to anterior translation in the 90° abducted arm is the inferior glenohumeral ligament complex (IGHLC) shown in Figure 1. The anterior and posterior bands of the IGHLC reciprocally tighten as the head is rotated. Any surgical treatment of anterior instability must consider the entire IGHLC, including both the anterior and posterior bands. The anterior band is most critical to limiting anterior translation in the abducted arm.
Posterior Translation Static Stabilizers

The primary restraint to posterior translation in the abducted shoulder is the posterior band of the IGHLC and, to a lesser extent, the anterior band. It has been established from cadaveric studies that the shoulder will not dislocate posteriorly even when the entire posterior capsule is detached from the glenoid. The rotator interval capsule (superior glenohumeral ligament, SGHL; middle glenohumeral ligament, MGHL; and coracohumeral ligament, CHL shown in Figure 2) is crucial to posterior static stability and must be addressed during surgical reconstruction of posterior instability.

Inferior Translation Static Stabilizers

The physical finding of an asymmetric sulcus sign in the adducted shoulder reflects incompetence in the rotator interval capsule. The SGHL and CHL (highlighted in Figure 3) are probably the most important contributors in inferior stability. The CHL can be of varied thickness. In many shoulders it plays a significant role in inferior stability in the abducted shoulder.
Laxity v. Instability

Although many patients may exhibit generalized laxity or looseness during an office shoulder examination, it is important to remember that a loose shoulder may not be an unstable one. Key symptoms of instability may include, but are not limited to:

- Apprehension signs
- A feeling of giving-way or sliding out in specific arm positions or under certain loading conditions
- Difficulty sleeping due to shoulder pain or discomfort
- Dead-arm syndrome during or after activities
- Pain during movement or lifting
- History of trauma or injury to the suspected shoulder

The clinician should also assess the patient’s overall joint flexibility, such as joint hyperextension as well as screen for systemic collagen disorders such as Ehlers-Danlos syndrome.

Examination Under Anesthesia (EUA)

A clinical pathologic diagnosis of instability must be made before bringing the patient to the operating room. The amount of capsulorrhaphy that is needed in the unstable shoulder can be readily determined by a side-to-side comparison of the available translation in both shoulders.

It can be generally assumed that normal shoulders should have symmetric translation and that any asymmetry reflects pathology in the unstable shoulder. The shoulder translation should be assessed anteriorly, inferiorly, and posteriorly in exactly the same manner for both shoulders.
Anterior and Posterior Assessment

The recommended convention for anterior and posterior assessment is to place the shoulder in 60–80° of scapula plane elevation with neutral rotation. An axial load is applied to center the humeral head in the glenolabral socket, and either an anterior- or posterior-directed force is applied.

The translation is graded as follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>No translation</td>
</tr>
<tr>
<td>1+</td>
<td>Translation of the humeral head up to, but not over, the labral rim.</td>
</tr>
<tr>
<td>2+</td>
<td>Translation over the labral rim but with spontaneous relocation of the humeral head once the force is released.</td>
</tr>
<tr>
<td>3+</td>
<td>Shoulder dislocates and remains dislocated after the force is withdrawn.</td>
</tr>
</tbody>
</table>

Inferior Assessment

The shoulder is placed in the fully adducted position and in neutral rotation for inferior translation grading. A sulcus sign is assessed by inferior directed force on the humerus (Photo 1). The distance between the anterior-lateral acromion and the greater tuberosity of the humerus is graded as follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Distance Between</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0–5 mm</td>
</tr>
<tr>
<td>1+</td>
<td>5–10 mm</td>
</tr>
<tr>
<td>2+</td>
<td>10–20 mm</td>
</tr>
<tr>
<td>3+</td>
<td>&gt; 20 mm</td>
</tr>
</tbody>
</table>
Patient Positioning — Technical Tips

**Lateral Decubitus**

The maximum amount of abduction should be 30° or less. For traction use 7 to 10 pounds; less weight is better. Use just enough weight to keep the arm in position and to avoid traction-related injuries. See Photo 2 for example of position.

**Beach Chair Position**

Use standard patient positioning and standard portal placement. Keep the anterior portal low to facilitate access to the inferior capsule. See example in Photo 3.

**Ground Pad Placement**

Good pad placement will help optimize thermal effects. Key points to remember about pad placement:

- Place on the same side as the surgery
- Place as close as possible to the operative site while avoiding bony prominances such as the ribs or iliac crest
- If placed on the abdomen, avoid possible folding or bending of the grounding pad when patient is repositioned or moved

**Portal Placement**

Monopolar thermal capsulorrhaphy uses standard arthroscopy portals for anterior and inferior instability patterns (Photo 4).

**Technical Tip:** Keep the anterior portal low, just under the subscapularis, for optimal access around the glenoid and humeral head.
Temperature Control Probe Selection

Two probe styles are available for this procedure, the TAC™-S and TAC-S Angled Probe. Surgeon preference dictates which probe to use. Both probes offer a malleable shaft for added utility.

Probe Settings

The Smith & Nephew Vulcan™ Generator automatically selects the proper power and temperature setting when a probe is connected. For thermal capsulorrhaphy, the settings are 40 watts of power and 75°C for temperature. During treatment, the generator monitors tissue temperature 50 times per second, automatically adjusting its power output to maintain the selected treatment temperature.

Before inserting the TAC-S thermal probe, bend the shaft to a gentle 20–30° arc to improve access. The curve will fit nicely under the humeral head while providing an additional 2 cm of reach to the seven o’clock position. Only use the Smith & Nephew Probe Bender to curve the shaft.

Posterior Portals — Posterior Instability

For patients with asymmetric posterior instability, an auxiliary posterior portal may aid in accessing the axillary recess between the five and seven o’clock positions. Place this portal approximately 1.5 to 2 cm below the original posterior portal. Using an 18-gauge spinal needle, begin entry nearly parallel and slightly lateral to the arthroscope (Photo 5).
Fluid Management
Since thermal capsulorrhaphy involves limited bleeding, high or excessive fluid pressure is not required to maintain adequate visualization and distention. Excessive or high fluid pressure can place significant internal pressure on the capsule. If too high, this pressure may exceed the contraction force exerted by the capsule during thermal treatment and limit or decrease the shrinkage effect.

High pressure also increases water flow through the joint from leaky or uncapped cannulas. This can negatively affect the surgeon’s ability to shrink tissue due to the cooling effect of the irrigation fluid as it moves through the joint.

For optimal results, a low pressure, static fluid environment will provide the best tissue response (contraction) as the lowest power and temperature setting. Always reduce pump pressure and plug or replace leaking cannulas.

Reestablishment of Labral Anatomy and Joint Dynamics
The main goal of thermal capsulorrhaphy is to reestablish the function of glenohumeral static stabilizers. The surgeon must also address any compromised labral pathology such as a Bankart or SLAP lesion. Thermal treatment cannot correct a torn or damaged labrum. Treatment of labral pathology can occur before, after, or during thermal treatment at the discretion of the surgeon. If labral reattachment is performed first, it may be a little easier to approximate the labrum to the glenoid.

The surgeon should avoid thermal treatment around areas of stress, such as a soft tissue anchor or suture. Basic science has shown a decrease in tissue strength during the early phases of the healing process. Keep a 5 to 10 mm distance from all suture or anchors when treating.

Patients with a compromised rotator interval may benefit by closure with suture.

Thermal Treatment Patterns (Grid v. Paintbrush)
In thermally treating the GHL complex, the surgeon can use a grid/strip pattern for subtle to moderate patterns of instability or a paintbrush (all areas) pattern for MDI or excessive degrees of instability. Usually the greater the degree of instability, the more contraction is required to reestablish stability.

Recent scientific studies have shown the grid treatment pattern to provide nearly equivalent amounts of tissue contraction versus the paintbrush technique. Moreover, a significant improvement in the rate of tissue healing was observed with the grid pattern. By leaving islands or rows of untreated tissue, the migration distance of the collagen-producing fibroblasts is reduced. A reduced fibroblast migration distance means a faster healing response.

Basic Thermal Surgery Treatment Guidelines
Maintain good tip contact with the target tissue. Approximately 1/2 to 1/3 of the probe tip should be depressed into the tissue for optimal heating and thermal effect.

Achieving a 2.5 to 3.0 mm thermal effect takes time. It will take 2 to 3 seconds after generator activation to reach contraction temperatures. Use the tissue’s contraction as a visual sign to begin probe movement.

Move the probe slowly while maintaining contact.

A slight color change usually occurs providing visual verification of treated areas.
Treatment Options and Portals Used

Refer to Figure 4 for the diagram of the treatment zones.

<table>
<thead>
<tr>
<th>Treatment Zones</th>
<th>Treatment Options/Portals</th>
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</thead>
<tbody>
<tr>
<td>1–4</td>
<td>Scope Posterior–Probe Anterior</td>
</tr>
<tr>
<td>5–8</td>
<td>Scope Posterior–Probe Posterior (Auxiliary Portal)</td>
</tr>
<tr>
<td>5–10</td>
<td>Scope Anterior–Probe Posterior</td>
</tr>
</tbody>
</table>

Important: Due to variability in the proximity of the axillary nerve, thermal treatment between the five and seven o’clock position (treatment zone between 1 and 5) is discouraged.

Asymmetric Anterior Translation Under EUA

The surgeon should perform arthroscopic labral repair as indicated plus monopolar thermal treatment of the following areas (refer to Figure 5):

- Anterior band of the IGHL
- Anterior-inferior pouch (avoid treatment in the inferior pouch between the five and seven o’clock positions)
- The MGHL
- Posterior band of the IGHL
- Posterior-inferior pouch

Treatment Tips:

Begin treatment laterally at the humeral insertion. Work along the humeral margin first and then move laterally.

Plan treatment as if painting yourself out of a room. Start distally away from your scope and work backwards. If you begin treatment too proximally, you may close out your access to distal portions of the capsule.
Asymmetric Posterior Translation Under EUA

The surgeon should perform arthroscopic labral repair as indicated plus monopolar thermal treatment of the entire available capsule (posterior-inferior glenohumeral ligament, posterior-inferior pouch, anterior-inferior glenohumeral ligament, anterior-inferior pouch, MGHL, SGHL, and CHL). Refer to diagram in Figure 6.

Important: If treating the inferior pouch, always reduce the generator’s delivered power from 40 to 25 watts to limit penetration depth.

Asymmetric Inferior Translation Under EUA

The surgeon should perform arthroscopic labral repair as indicated plus monopolar thermal treatment of the rotator interval capsule (SGHL, MGHL, and CHL). Refer to diagram in Figure 7. The superior endpoint of the thermal application is the biceps tendon. An apparent open rotator interval lesion, if present, will require a structural repair and is beyond the scope of thermal capsulorrhaphy.

Internal Impingement

The surgeon should perform arthroscopic labral repair as indicated, plus monopolar thermal treatment of the rotator interval capsule (SGHL and MGHL). Refer to diagram in Figure 8. This procedure is suggested for subtle instability patterns and overhand athletes.
Thermal Capsulorrhaphy

Rehabilitation Following Monopolar Thermal Capsulorrhaphy

A careful regimen of physical therapy and rehabilitation following monopolar thermal capsulorrhaphy is at least as important as the surgery itself. The reason lies in the fact that the thermally modified collagen is denatured. The contracted capsular construct is held together by a collagen matrix. For the clinical outcome of the procedure to be successful, the bio-replacement of the treated collagen framework is essential.

The recovery of motion and function from this procedure, therefore, must be deliberately paced. Rehabilitation that is too fast can stretch the treated tissue and lead to a failed outcome. Rehabilitation that is too slow might retard a patient’s progress in achieving full range of motion.

Patients can and will heal at different rates. Monitoring their recovery can allow for titration of therapy activities.

The following generalized protocols are recommended for predictable recovery of motion and strength.

Phase One: Initial Immobilization

The duration of initial immobilization is determined at the time of surgery and based primarily upon the degree of capsular laxity and the pattern that was addressed. As a rule, the higher the degree of instability, the longer the immobilization time. During immobilization, all patients are allowed range of motion exercises of the wrist and elbow as well as gentle Codman exercises with the elbow supported. Shoulder abduction and flexion exercises are not allowed in any patient and external rotation past 0° is highly discouraged in this phase.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Length of Initial Immobilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior stabilization</td>
<td>2–3 weeks</td>
</tr>
<tr>
<td>with labral repair</td>
<td></td>
</tr>
<tr>
<td>Unidirectional stabilization</td>
<td>3 weeks</td>
</tr>
<tr>
<td>without labral repair</td>
<td></td>
</tr>
<tr>
<td>Posterior stabilization</td>
<td>4–5 weeks</td>
</tr>
<tr>
<td>MDI</td>
<td>4–6 weeks depending on degree of instability</td>
</tr>
</tbody>
</table>

For anterior, anterior-inferior, inferior, and MDI (anterior dominant) instabilities, 3 weeks in a sling pillow is recommended. For posterior, posterior-inferior, and MDI (posterior dominant) instabilities, 4+ weeks in a sling is recommended (consider neutral rotation orthosis).

Phase Two: Protected Range of Motion

Phase Two begins 2 to 4 weeks out of the sling, at which time the patient is allowed protected active motion, but absolutely no lifting, pushing, or pulling greater than 5 pounds. The patient continues this regimen for 6 to 12 weeks, depending on the degree of instability.

Anterior or MDI with primary anterior component: external rotation limited to 45° with elbow at side and 45° with the arm abducted.

Range of motion allowed is 140° elevation, 40° external rotation with the arm at the side, and internal rotation with the hitchhiking thumb to L1.

Usually these parameters are reached quickly; if so, the patient is instructed to pause in the rehabilitative progression until it is time for Phase Three. The patient and therapist are reminded of the “pace” of recovery.
Phase Three

The patient should progressively push for full range of motion, with the goal of achieving full ROM between 9 to 12 weeks post-surgery (but no sooner). Rehabilitative strengthening can be aggressively progressed. Phase Three lasts for about four weeks.

Phase Four

The patient should begin weightlifting at 12 weeks post-surgery. At this time, the shoulder capsule has reached approximately 80% of its presurgery strength, and the limits of lifting, pushing, and pulling are withdrawn. Sport activities not involving contact or overhead motions can be fully resumed. However, the patient may:

Return to contact sports at 4 to 5 months post-surgery, assuming excellent strength restoration.

Begin overhead throwing rehabilitation at 3 months post-surgery, and may fully return to overhead throwing and racquet activities at 5 to 12 months post-surgery according to progression.

Important: Thermal capsulorrhaphy is a “biological remodeling” process, and clinical improvement can take up to one year for collagen to reorganize and become structurally sound.

References

Additional Instruction

Prior to performing this technique, consult the Instructions for Use documentation provided with individual components — including indications, contraindications, warnings, cautions, and instructions.

Courtesy of Smith & Nephew, Inc., Endoscopy Division

Caution: U.S. Federal law restricts this device to sale by or on the order of a physician.